

**Long-Term Index Site Monitoring Project:
2002 Physical Habitat Characterization**

**Clark County Public Works
Water Resources Section**

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2002 LISP Physical Habitat Characterization

Background

Physical habitat monitoring is one component of the Long-term Index Site Project (LISP) conducted by Clark County Public Works Water Resources (Water Resources). The LISP utilizes a holistic monitoring approach designed to characterize stream health conditions over time at a set of ten stormwater-influenced stream reaches across Clark County. The LISP includes physical habitat, water quality, biological, and hydrologic components.

LISP stations are located primarily on public lands for convenience and to ensure long-term accessibility. As a secondary consideration, stations were selected to include a range of watershed conditions typically found within Clark County. However, the stations were not selected to be statistically representative of stream health throughout the county. Therefore, results are not intended to be extrapolated to other stream reaches.

2002 physical habitat data were collected using EPA Environmental Monitoring and Assessment Program (EMAP) protocols. The protocols result in more repeatable and quantitative data collection than the simplified protocols utilized in 2001. Data are also comparable to habitat data collected by other agencies. Physical habitat data will be collected periodically over the course of the LISP project, which will enable some level of comparison between years at each site. Due to the small number of LISP sites, statistical power of some analyses may be limited. Regardless, when combined with water quality, hydrologic, and biological monitoring results, the physical habitat characterizations will contribute to our overall understanding of the condition of LISP reaches over time.

Purpose and Scope

The goal of the LISP is to identify trends in stream health at a set of stormwater-influenced streams. The objectives of physical habitat data collection are to characterize current stream conditions, compare each site to appropriate reference conditions, and assess changes over time at individual stations.

Water quality status at the LISP reaches during 2002 was addressed by calculating the Oregon Water Quality Index (OWQI) for each reach as part of the 2003 Clark County Stream Health Report (Clark County, 2003). Biological health for the LISP reaches was assessed as part of the same report based on 2001 and 2002 benthic macroinvertebrate Index of Biological Integrity (B-IBI) scores. Hydrologic data collection was not underway in 2002.

This document summarizes the physical habitat characterization portion of the 2002 LISP. 2002 was the first year of LISP physical habitat data collection using EMAP protocols. Therefore, this summary focuses not on trends or changes in condition, but rather on establishing a baseline characterization of habitat conditions at each site. Discussions of watershed attributes, stressor identification, and causal factors for the observed conditions are beyond the scope of this report. These issues may be addressed in future Water Resources projects.

This summary includes descriptions of individual habitat metrics and indices, results of multi-metric index calculations, a general comparison of LISP sites to reference conditions in the Willamette Valley and Cascades ecoregions, and an overall habitat characterization for each LISP reach based on a number of physical habitat attributes.

Figure 1. Location of the ten LISP monitoring sites, 2002.



Methods

Quantitative habitat assessments were made using the methods described in the USEPA's Environmental Monitoring and Assessment Program (EMAP) Western Pilot Study: Field Operations Manual for Wadeable Streams (Peck et al., eds. 2001). Standard procedures used for field data collection are also described in the county's Standard Procedures for Monitoring Activities: Clark County Water Resources Section (2002).

In the EMAP protocol, assessment reach lengths are defined as a distance of 40 times the wetted width at each station, or a minimum of 500 feet. Reach lengths assessed in the 2002 LISP ranged from 500-800 ft. Along the defined reach, 11 transects are laid out at equal distances. Depending on the specific metric, data are collected at each transect or continuously throughout the reach.

EMAP physical habitat protocols are designed for monitoring applications where robust, quantitative descriptions of reach-scale habitat are desired, such as site classification, trend interpretation, and analysis of possible causes of biotic impairment (Peck et al., 2001). They are designed to collect quantifiable measurements about seven general physical habitat attributes important in influencing stream ecology:

- Stream size and channel dimensions
- Channel gradient
- Channel substrate size and type
- Habitat complexity and cover
- Riparian vegetation cover and structure
- Anthropogenic alterations
- Channel-riparian interaction

EMAP Metric Calculation

The EMAP physical habitat protocols produce a large amount of data which must be condensed into reach-scale metrics describing various aspects of physical habitat. These include simple statistical summaries, areal cover estimates, proximity-weighted disturbance indices, woody debris abundance, residual pool dimensions, sinuosity, and bed substrate indices.

Raw data were verified, validated, and analyzed using Statistical Analysis Software (SAS) algorithms developed by EPA EMAP staff. Data validation and analysis were performed by Water Resources staff under the guidance of EMAP staff at the USEPA Western Ecology Division's National Health and Environmental Effects Research Laboratory in Corvallis, Oregon.

The SAS algorithms calculate approximately 250 habitat metrics in 11 categories. A subset of 49 metrics used most often in multivariate or habitat analyses were recommended by EPA, including a balanced set of 18 "most important" metrics representing each of the seven habitat attributes listed in *Methods* above. Many of these recommended metrics, plus additional metrics from among the 250 calculated are reported in this summary. Appendix A contains a subset of metric scores for the LISP sites.

Applicability of the EMAP protocols

One of the objectives of the LISP is to produce data which can be shared with other agencies for a variety of uses. Various researchers (including Scholz and Booth, 1997, Montgomery and MacDonald, 2002, May, 1997, and Kaufmann et al., 1999) have evaluated physical habitat parameters

in an effort to determine which metrics are precise enough to reliably measure changes in stream condition, and which are most appropriate for measuring impacts from urbanization.

Appendix B contains a table listing recommended metrics from the above researchers. Most of the recommended metrics are either directly provided by EMAP data, or may be derived from EMAP data if desired. Many, but not all, of the literature-recommended metrics are presented in this summary either individually or as part of calculated indices.

It is important to note that additional metrics can be provided by these protocols to meet the needs of other groups or agencies. For instance, the EMAP habitat protocols produce data that may be used to address the habitat portion of the National Marine Fisheries Service Matrix of Pathways and Indicators (NMFS, 1996). Appendix B contains a table showing the NMFS Matrix for reference.

Precision

Precision is a measure of the amount of variability between repeat measurements, with lower variability indicating higher precision. The higher the precision, the more repeatable or consistent the measurement. The table in Appendix A contains two estimates of precision for the EMAP habitat metrics: root mean square error (RMSE) and signal-to-noise ratio (S/N). The RMSE is reported in the same units as the metric, and is equivalent to the pooled standard deviation of repeat measurements of a given metric. The S/N compares the variance of a metric observed across a regional sample of streams (“signal”) with the “noise” variance resulting from field measurements during the sampling season (Kaufmann et al., 1999).

The precision estimates in Appendix A were compiled by Kaufmann et al. (1999), based on measurements collected from a large number of Oregon streams between 1993 and 1996. The lower the RMSE, and the higher the S/N, the better the precision. A S/N of 6-18 indicates high precision, 2-6 indicates moderate precision, and less than 2 indicates low precision.

In general, metrics based on quantitative measurements (e.g. slope, canopy density) are the most precise, while visual determinations of cover and channel-unit types (e.g. fish cover estimates, % pool) have relatively low precision due to the subjective nature of visual interpretation. Semi-quantitative measurements (e.g. substrate size, large woody debris tally) are intermediate in precision (Kaufmann et al., 1999). Metrics used in this summary fall into all three categories. Low precision does not necessarily preclude a metric from providing useful information, especially in the case of overall habitat characterizations like this one. However, future statistical tests, regression analyses, or correlation studies using EMAP data should be based on metrics with high precision whenever possible.

Precision estimates were not produced specifically for the LISP. The number of LISP sample sites is not large enough to calculate reliable precision estimates. Therefore, it is assumed that LISP habitat metrics reflect the general precision estimates compiled by Kaufmann et al. (1999). To increase precision, LISP sites were sampled using a consistent team of technical staff. All team members also participated in field training and practice sessions to promote consistency in field measurements and interpretation.

Reference conditions

Physical habitat assessment or characterization generally requires an estimate of expected or attainable condition to which study sites may be compared. Reference condition is based on the idea that for any given water body there exists a range of natural conditions in the absence of human influence. Reference condition is characterized by a set of attributes at undisturbed or minimally disturbed sites

characteristic of a water body type in a region (Drake, 2003 draft). Study sites are then compared to these expected reference conditions.

The Oregon Department of Environmental Quality (DEQ) has begun establishing reference conditions for the Willamette Valley and Cascades ecoregions. Because the LISP study sites lie within these two ecoregions, some preliminary results were made available to Clark County for use in this summary. DEQ assigns a letter grade (A-C) to each reference site, according to the quality of the site. An “A” grade indicates ideal watershed and stream conditions, or virtually no human disturbance. “B” sites represent minimally disturbed or “good” conditions with some, but not extensive, human disturbance. A “C” grade indicates marginal watershed and stream conditions for a reference site, with obvious human disturbance. “C” sites are the “best available” for the region, and will be replaced if better quality reference sites are located.

Sites graded D-F do not qualify for use as reference sites (Drake, 2003 draft). Given the high level of human disturbance present throughout the Willamette Valley ecoregion, DEQ has had difficulty locating sites with high quality reference conditions. The two Willamette Valley ecoregion reference sites provided by DEQ are both graded “C”, or marginal. Two additional reference sites in the Cascade ecoregion were provided, and these sites scored “A” and “B”.

In this summary, LISP sites are compared to reference conditions by calculating a simple Habitat Quality Index (HQI) developed by Washington Ecology, as described in the next section.

In addition to the reference conditions provided by DEQ, various researchers and agencies have published guidelines for desirable habitat conditions. Some of these guidelines are described below, and several individual metric scores for the LISP sites are compared to these guidelines as part of the individual site characterizations at the end of this summary.

Description of metrics and indices

Channel morphology

XDEPTH:	mean thalweg depth (cm)
XWIDTH:	mean wetted width (m)
XWXD:	mean wetted width x depth (m ²)
PCT_POOL	Percent all pool types (area based on length)
PCT_FAST	Percent falls + cascades + rapids + riffles (area based on length)

Mean thalweg depth and mean wetted width x depth are reach-level means used in calculating indices of stream “flashiness”, and mean wetted width gives an indication of stream size at baseflow.

The percent “pool” and “fast” categories are reach-level percentages. Because the data are collected using systematic spacing, the percentiles are estimates of the spatial distribution of each characteristic throughout the reach. Subtracting the percent pool from the percent fast value gives an estimate of the percentage of glide area. Peterson et al. (1992) suggests that pools should comprise ~50 percent by area in streams with a gradient <3%, and that pools and riffles should each comprise 40-60% of the stream surface area. A 55% pool percentage by surface area has been recommended for streams with a gradient of 0-2% (WDFW and Western Washington Treaty Tribes 1997; WDNR 1997).

Channel x-section and bank morphology

XBKF_W:	mean bankfull width (m)
XBKF_H:	mean bankfull height (m)

Mean bankfull width and mean bankfull height are reach-level means used in calculating indices of stream “flashiness”.

Channel sinuosity and slope

SINU:	channel sinuosity
XSLOPE:	water surface gradient over reach (%)

Sinuosity is a measure of the degree of “twisting” of the stream channel as observed from overhead. It is measured as the distance along the channel “as the fish swims” divided by the distance “as the crow flies” between the two ends of the sample reach. Lower gradient streams tend to have increased sinuosity and a pool-riffle geomorphology as the stream loses energy and begins to meander across a wider floodplain, while high gradient streams often display less sinuosity as the stream flows in a step-pool or cascade channel in a steeper, confined valley. In lower gradient streams, anthropogenic activities such as diking channelization, and altered hydrology may decrease sinuosity and, subsequently, habitat availability and complexity.

Gradient is an important determinant of stream power and expected habitat and biological condition. In the EMAP protocols, “high gradient” streams are streams with a gradient >5%. Gradient is also used in the calculation of stream bed stability metrics for this summary.

Residual pool

RP100:	mean residual depth ($\text{m}^2/100\text{m}$ reach length = cm)
TOTPVOL:	residual volume for the entire reach (m^3/reach)

A residual pool is defined as an area in a stream that would contain water even at zero discharge, due to the damming effect of the downstream riffle crest (Lisle 1982, 1986, 1987). Residual pool depths and volumes give an indication of available habitat space during very low flows.

Mean residual depth is also used in this summary to calculate an index of stream flashiness.

Substrate size and composition

XEMBED:	substrate mean embeddedness (%)
PCT_BIGR:	substrate % coarse gravel and larger (>16mm)
PCT_SAFN:	substrate % sand + fines (<2mm)
LSUB_DMM	Log of geometric mean substrate diameter (converted to D_{50})

The embeddedness metric is a mean calculated from visual estimates collected at 11 cross-sections throughout the reach. The other metrics are based on systematic pebble counts, which can be directly reduced to whole-reach substrate characterizations by calculating percentages within various size classes. The PCT_BIGR metric is used in this summary to calculate an overall index of habitat quality, while PCT_SAFN and LSUB_DMM (converted to D_{50}) are used as individual indicators of substrate composition.

Substrate characteristics are often sensitive indicators of the effects of human activities on streams (MacDonald et al. 1991). Decreases in the mean substrate size and increases in the percentage of fine sediments may destabilize channels and indicate changes in the rates of upland erosion and sediment supply (Dietrich et al., 1989). Changes in substrate size are often indicative of catchment and streamside disturbances.

As fine particles accumulate, they also fill the spaces between coarser bed materials, reducing habitat availability and the circulation of oxygenated water (Kaufmann, et al., 1999). A study by McHenry et

al. (1994) found that if more than 13% fine sediment (defined as <0.85mm) intruded into redds, it resulted in the death of almost all steelhead and coho eggs.

The NMFS Matrix of Pathways and Indicators (1996) considers streams with a dominant substrate of gravel or cobble, or streams with embeddedness <20%, to be in a properly functioning condition. NMFS (1996) also considers <12% fines in gravel to be properly functioning condition in streams, with between 12% and 17% fines indicating “at risk” conditions and >17% fines indicating a “not properly functioning” condition.

Bed substrate stability

LRBS_BW4: $\log_{10}[\text{relative bed stability}]$

LRBS_BW4 is a measure of stream bed textural “fining” that occurs in response to increasing upland erosion, and the increased mobility or instability of the stream bed in response to these increased inputs of fine sediment (Kaufmann, et al., 1999). The size composition of a streambed depends on the stream’s sediment transport capacity, which is affected by basin and channel characteristics such as topography, climate, land cover, slope, watershed area, runoff regime, and channel roughness.

Good quality in-channel habitat is generally neither excessively stable nor excessively unstable (Kaufmann et al., 1999). Some movement of the streambed is needed to maintain habitat quality and complexity. However, human activities can cause large amounts of sediment to be transported to streams, resulting in high bed mobility and poor habitat. Channelization, impoundments, clearing, logging, farming, and road building may increase scouring or sedimentation, destabilize stream banks, and otherwise impact stream bed substrate size and mobility.

The bed stability metric compares the size range of streambed material with the stream’s erosive capability. If most of the streambed sediments are finer than the size the stream is capable of moving, then the streambed is relatively unstable.

Most relatively undisturbed watersheds will have LRBS values near or slightly above zero. Highly disturbed streams typically had LRBS values <-2.0 in Western Oregon (Kaufmann, et al., 1999).

A high positive value of LRBS, say 3.0, indicates an extremely stable, immovable stream substrate, for instance an armored channel. Conversely, very small values of LRBS, say -2.5, indicate a channel substrate that is frequently moved by even small flow events. LRBS values are logarithms, so a value of -2.5 describes a stream in which bankfull flows have sufficient force to move particles with a diameter 300 times larger than the geometric mean particle size in the streambed (Kaufmann, et al., 1999).

Fish cover

XFC_NAT: sum of cover from LWD, brush, vegetation, boulders, banks
XFC_BIG: sum of cover from LWD, boulders, banks, and human structures

Complex habitats with abundant cover generally support greater biodiversity than habitats which lack cover (Kaufmann, et al., 1999). In-stream cover provides refuge for fish and benthic organisms from both predators and physical conditions such as high flows.

The fish cover metrics consist of visual estimates of eight specific types collected at 11 cross-sections throughout the reach. Whole-reach averages are calculated for individual and combined cover types.

In this summary, XFC_BIG is used in the calculation of an overall index of habitat quality, and XFC_NAT is used to indicate the amount of cover present from natural stream and streambank features.

Large woody debris

C1W: LWD in active channel (pieces/reach) – sum of all size classes
The Large Woody Debris (LWD) metric consists of a tally of all wood pieces in the reach with a diameter >10 cm (4 in) and a length >150 cm (5 ft). Total LWD counts are grouped into five size classes after the initial tally. The C1W metric is the sum of all size classes, expressed as pieces/reach. LWD is an important component in determining stream habitat quality. LWD acts as fish cover, decreases current velocity, adds structure, and plays an important role in pool formation (Kaufmann, et al., 1999).

Expected LWD frequency for small streams in natural forested ecosystems in western Washington include 150-400 pieces per mile (Ralph et al., 1994) and 140- 670 pieces per mile (Beechie and Sibley, 1997). The NMFS (1996) considers the minimum for “properly functioning” streams west of the Cascade Mountains to be 80 LWD pieces/mile (~8 pieces/500 ft) having >2 ft diameter and >50 ft length.

Riparian cover (densiometer)

XCDENBK: mean % canopy density at bank
XCDENMID: mean % canopy density midstream

The riparian cover densiometer metrics are used in this summary to calculate indices of overall riparian condition. XCDENMID is also used individually as an indicator of stream shading.

Riparian vegetation is important to channel structure, shading, large woody debris recruitment, wildlife corridors, buffers from human disturbance, and as an indicator of bank stability and the potential for inputs of organic material (Kaufmann, et al., 1999).

The densiometer metrics listed above are whole-reach means of stream shading. Because the data are systematically spaced, the means are spatially representative of canopy density along the entire sampled reach.

Riparian vegetation cover/structure

XCL: riparian canopy (>5m high) cover – trees >0.3 m DBH
XCMGW: riparian woody cover, sum of 3 layers
ip_score: riparian invasive plant species, sum of f_ENGIVY, f_HIMBLA, and f_REECAN

The riparian vegetation cover/structure metrics consist of visual cover class estimates in three layers at each of 22 riparian vegetation plots distributed through the sample reach. The three vegetation layers are canopy (>5 m high), mid-layer (0.5-5 m high), and ground cover (<0.5 m high). The metric summaries are whole-reach averages and may range from 0.0 to 3.0 (possible 100% coverage (1.0) in each layer). Each invasive species receives an individual score ranging from 0 to 1.00 (present at 0% to 100% of the reach). The ip_score metric is the sum of reach level proportions for all invasive plant species present.

The XCL and XCMGW metrics are used in this summary in the calculation of overall riparian condition indices. The ip_score is a percentage measuring the extent to which invasive species have colonized the reach.

Human disturbance

W1_HALL: riparian human disturbance index (proximity-weighted sum)

Evidence of human activities in or near the stream channel may serve as direct stream habitat quality indicators or diagnostic indicators of human-caused stress to the stream (Kaufmann et al., 1999). In-channel disturbances can include pipes, bridges, culverts, channelization, or trash, while near-channel disturbances might include lawns, roads, buildings, or pastures.

The human disturbance metrics are proximity-weighted indicators based on the presence of 11 pre-defined types of human land use or disturbance. The presence of each disturbance is based on visual estimates collected at 22 plots distributed through the sample reach.

W1_HALL is used in this summary as a component of indices of riparian condition. It is also an independent indicator of the extent of human disturbance from all 11 types of disturbances throughout the sample reach.

Multi-metric indices

Habitat Quality Index (HQI)

A simple HQI was developed by Glen Merritt, Washington Department of Ecology, for a report titled Biological Assessment of Small Streams in the Coast Range Ecoregion and the Yakima River Basin (1999). A slightly modified version of the HQI is used in this summary: In Merritt's original HQI, the metric XFC_LRG was used, representing areal cover from large woody debris and boulders. In 2002, the XFC_LRG metric was not available, and the metric XFC_BIG was substituted. XFC_BIG includes areal cover from overhanging banks and human structures in addition to LWD and boulders.

The HQI rates site conditions relative to the best conditions represented in the site's class (ecoregion), based on a combination of four habitat metric scores. For this summary, site class was defined as the ecoregion occupied by the majority of the watershed area upstream of the sample reach. Seven of the eight sites were located in two sub-regions of the Willamette Valley ecoregion (3a and 3d) (Omernik and Gallant, 1986). These seven sites were assigned to the same "class", and are directly compared in this assessment. The final site, JNS060, was located in the Cascade ecoregion (4a).

Reference sites provided by Oregon DEQ (see Reference Condition section) were also included in each ecoregion class so that LISP sites could be compared to reference site conditions in each ecoregion. Two reference sites were provided for the Willamette Valley ecoregion, and two for the Cascades ecoregion. Note that both Willamette Valley reference sites were judged "marginal" by DEQ due to clear evidence of human impacts. When calculating the HQI, the scores for the two reference sites in each ecoregion were averaged to provide a single reference site score in each ecoregion.

Four habitat metrics were used to calculate the HQI:

SDWXD	(standard deviation of thalweg depth x wetted width, as a measure of channel complexity)
PCT_BIGR	(substrate % coarse gravel and larger (>16mm))
XFC_BIG	(sum of cover from large wood, boulders, overhanging banks, and human structures)
XCDENMID	(mean % canopy density midstream)

A higher score is better in all categories. A score was first calculated for each of the four metrics by dividing the metric value by the maximum value of that metric for the stream "class". The composite HQI was then created by calculating the sum of the four habitat scores for the site divided by the

maximum sum of scores for the stream class. The HQI is normalized so that the highest scoring site receives a score of 100 on a scale of 0 to 100. Note that all results are relative to the highest quality score in the class, *not necessarily* to a site with excellent habitat quality.

Riparian Condition Indices

QR1:

QR1 is a riparian habitat quality index developed by Phil Kaufmann at USEPA, and used in Ecology's 2002 305(b) report (Butkus, 2002).

QR1 uses the following habitat metrics:

XCMGW	(riparian woody cover, sum of 3 layers)
XCDENBK	(mean % canopy density at bank)
W1_HALL	(riparian human disturbance index)

QR1 is calculated as follows:

QR1 = geometric mean of QRveg1, QRveg2, and QRDist1,
where

if XCMGW ≤ 2.0 , then QRveg1 = $0.1 + 0.9(XCMGW/2.00)$
if XCMGW > 2.0 , then QRveg1 = 1

QRveg2 = $0.1 + (0.9(XCDENBK/100))$

QRDist1 = $1/(1 + W1_HALL)$

The resulting value for QR1 ranges from 0 to 1. EPA has defined values < 0.5 to be indicative of "poor" riparian condition, values 0.5 to 0.63 "fair", and values > 0.63 "good" (Butkus, 2002).

RCOND:

RCOND is a riparian habitat quality index developed by Dr. Philip Kaufmann at USEPA, and used in a manuscript currently under review (Kaufmann and Larson, 2003, in review).

RCOND uses the following habitat metrics:

XCL	(riparian canopy (> 5 m high) cover- trees > 0.3 m DBH)
XCMGW	(riparian woody cover, sum of 3 layers)
W1_HALL	(riparian human disturbance index)

RCOND is calculated as follows:

RCOND = geometric mean of (XCL) (XCMGW)($1/(1 + W1_HALL)$)

The index ranges from 0 to 1, decreases with increases in streamside human activities, and increases with increasing large diameter tree cover and riparian vegetation complexity. Kaufmann and Larson (2003, in review) define five classes of riparian condition based on the RCOND index and its subcomponents:

Best = top 25th percentile of RCOND (> 0.58), but W1_HALL < 1.0 , XCMGW > 1.25 , and XCL > 0.3

Good = top 25th percentile of RCOND, but not meeting subcomponent criteria for "best"

Medium = within interquartile range of RCOND (> 0.30 to < 0.58)

Poor = lower 25th percentile of RCOND (< 0.30), but not meeting subcomponent criteria for "worst".

Worst = lower 25th percentile of RCOND, but W1_HALL > 3.0 , XCMGW < 0.625 , and

$$XCL < 0.15.$$

Hydrologic Flashiness Indices

“Hydrologic flashiness” is an indication of the tendency of a stream to experience extremes in flow regime. A “flashy” stream may exhibit storm hydrographs that are much steeper and of shorter duration than normal. Flashiness is often associated with streams in watersheds having large amounts of impervious surface area or cleared land, as stormwater volumes tend to increase and runoff reaches the stream more quickly. Conversely, a flashy stream may experience very low flows during dry weather due to lack of groundwater recharge during wet weather. Flashy streams often exhibit wide channels that have been scoured by storm flows. During baseflow the stream may only fill a fraction of the channel.

Three indices of hydrologic flashiness have been developed by Dr. Philip Kaufmann at USEPA (Kaufmann, personal communication, 2003). All three indices were calculated for this characterization:

Flashrt1 uses the following habitat metrics:

XBKF_H	(mean bankfull height)
XDEPTH	(mean thalweg depth)

Flashrt1 is calculated as follows:

$$\text{Flashrt1} = ((100 * \text{XBKF_H}) + \text{XDEPTH}) / \text{XDEPTH}$$

Flashrt2 uses the following habitat metrics:

XBKF_H	(mean bankfull height)
XDEPTH	(mean thalweg depth)
RP100	(mean residual depth)

Flashrt2 is calculated as follows:

$$\text{Flashrt2} = ((100 * \text{XBKF_H}) + \text{XDEPTH} - \text{RP100}) / (\text{XDEPTH} - \text{RP100})$$

Flashrt3 uses the following habitat metrics:

XBKF_H	(mean bankfull height)
XBKF_W	(mean bankfull width)
XWXD	(mean wetted width x depth)

Flashrt3 is calculated as follows:

$$\text{Flashrt3} = ((\text{XBKF_H} * \text{XBKF_W}) + \text{XWXD}) / \text{XWXD}$$

Results

Results are presented as follows:

- 1) Habitat Quality Index (HQI) scores for the LISP sites and ecoregion reference sites are shown in a single chart, with Willamette Valley and Cascades ecoregion sites grouped separately.
- 2) Riparian condition index and stream flashiness index charts include LISP sites only. Sites are not separated by ecoregion, and reference sites are not included.
- 3) Each station is characterized independently in a one-page summary of various metric and index results.

Habitat Quality Index

Figure 2 compares the LISP site HQI scores to reference site scores from the Willamette (left side of chart) and Cascades (right side of chart) ecoregions. The Willamette reference sites represented in the chart were deemed grade “C” or “marginal” reference sites by DEQ due to the clear presence of human impacts at those sites (Drake, 2003 personal communication). Recall, however, that the HQI automatically scores the best site in a class (ecoregion) as “100”, and all other sites are scored relative to the highest scoring site.

Despite the grade “C” reference conditions, the mean reference site score still exceeded all seven LISP site scores for the Willamette ecoregion, suggesting significant human impact at all LISP sites in that ecoregion. However, the index also suggests that certain sites are considerably more impacted than others.

In the Cascades ecoregion, the reference sites were rated “A” and “B”, indicating that they represent good to pristine conditions. The LISP site located in the Cascade ecoregion (JNS060) scored considerably lower than the mean reference site score, but still displays relatively good habitat quality for the Cascade ecoregion.

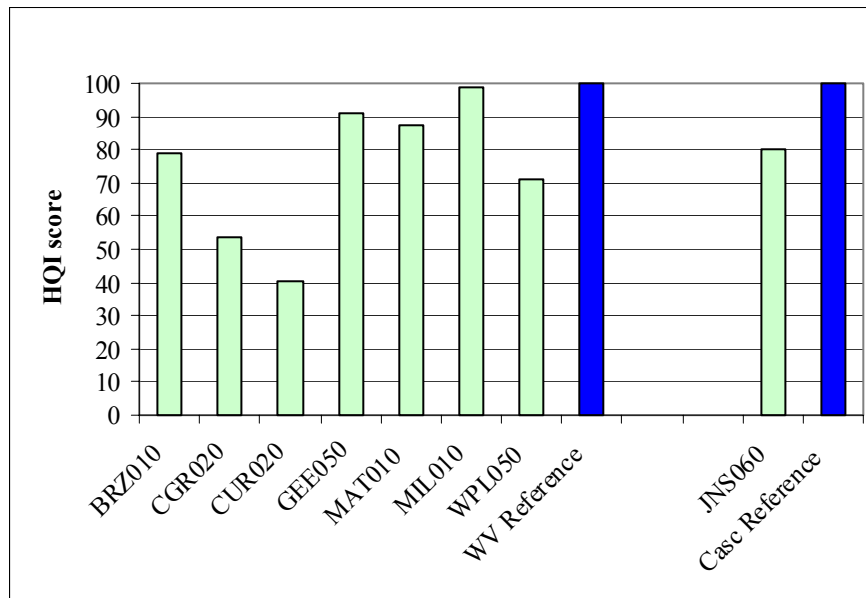


Figure 2. 2002 Habitat Quality Index (Merritt et al., 1999) scores for the LISP stations in the Willamette Valley (left) and Cascades (right) ecoregions, compared to mean scores of two reference sites in each ecoregion (Drake, 2003 personal communication).

Riparian Condition

Figure 3 shows the index scores for QR1 and RCOND. Riparian condition classes are also shown for each site and index. Based on these two indices, six of the eight monitored sites had good to very good riparian condition in 2002. One site (CGR020) scored in the fair range, and one site (CUR020) scored poorly due to lack of tree canopy cover.

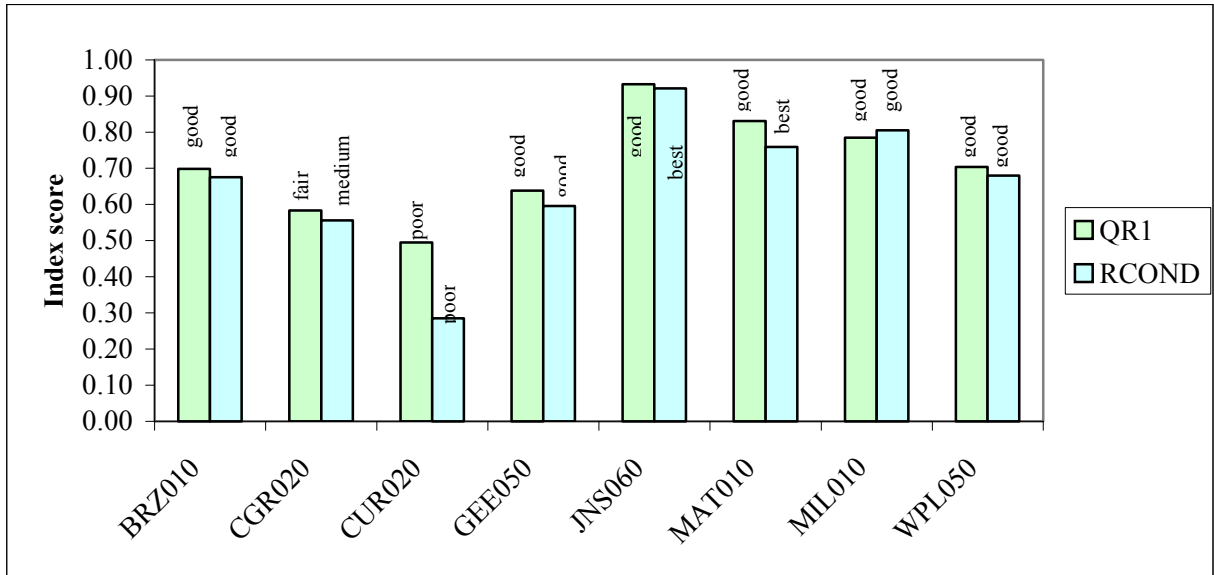


Figure 3. Riparian habitat condition index scores (QR1 and RCOND, developed by Philip Kaufmann, USEPA) and riparian habitat quality classes for LISP stations, 2002.

Stream flashiness

Figure 4 shows the results of the three flashiness indices, plus the mean of the three scores. The mean is included because the indices are calculated based on slightly different metrics and it is unknown which index gives the most accurate representation of flashiness. Although the indices do not have a theoretical maximum or minimum, they do allow a relative comparison between sites.

Most LISP sites appear to display somewhat flashy conditions, but only one site (CGR020) was clearly more flashy than the remainder of the sites. CUR020 was clearly the least flashy of the eight sites, with the remainder of the six sites clustered between the two extremes. These results agree with staff observations of the LISP sites during storm events.

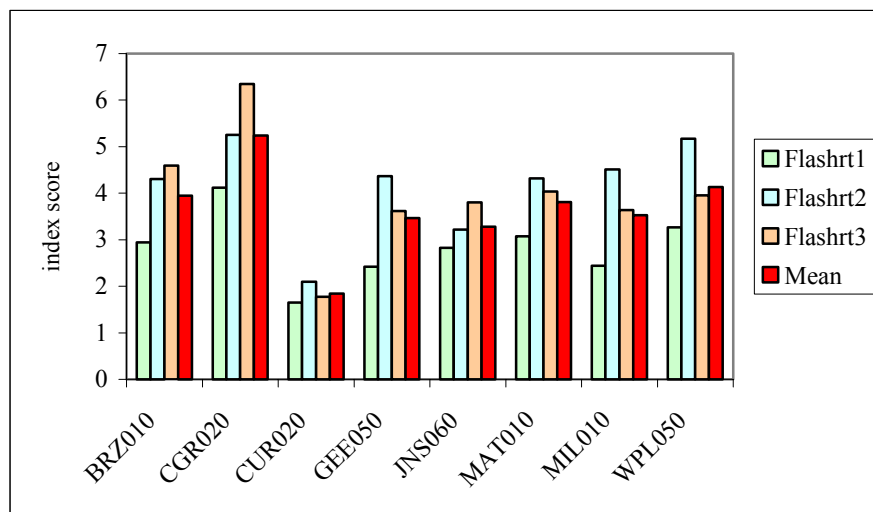


Figure 4. Indices of hydrologic flashiness (Flashrt1, Flashrt2, Flashrt3, developed by Philip Kaufmann, USEPA) for LISP stations, 2002, and mean value for each station.

Site Characterizations

The remainder of this summary consists of a one-page, overall habitat characterization for each LISP reach, based on a number of EMAP habitat metrics and index scores.

Most of the comments relating to habitat quality in the “characterization” column are based on published literature values and scoring criteria as described in the Description of Metrics and Indices section above. However, published criteria for some metrics were not available (e.g. areal extent of natural fish cover). In those cases, descriptive characterization comments (e.g. “fish cover sparse”) were applied based on the metric score at each site, the range of possible metric values, and professional judgment. Appendix A includes descriptions and scores for individual metrics. Index score calculations are contained in Appendix C.

Characterizations are intended to provide general site background and a broad summary of current physical habitat conditions. The metrics and indices presented include recommended attributes for measuring stormwater and urbanization impacts (see Appendix B). Additional attributes are included to provide more comprehensive information about the sites with regard to salmonid habitat and overall ecological integrity (see Appendix C).

The following characterizations are intended to provide an accurate picture of current site conditions and establish a baseline from which to measure change in future conditions.

Breeze Creek station BRZ010 (2002)

Reach location and watershed description:

The Breeze Creek watershed has a drainage area of ~3.3 mi² above the index reach. Current land cover in the drainage is primarily pasture and forest land, with an expanding area of urban development in the lower watershed around the city of La Center and rural residential development throughout the drainage. For much of its length, Breeze Creek flows in a narrow, steep-sided canyon with intact riparian forest. Upland areas are largely cleared or open. Stormwater inputs to Breeze Creek consist of an expanding network of piped urban storm sewers in the lower watershed within the town of La Center, and limited roadside ditches in the unincorporated upper watershed. Road density above the index reach is ~7.0 mi/mi² (2001 data).

The index reach is located near the mouth of Breeze Creek, approximately 300 ft upstream of its confluence with the East Fork Lewis River. The reach is characterized by pool-riffle morphology and a low gradient (1.9%), but is also fairly straight with a low sinuosity of 1.2. Mean wetted width at baseflow was ~11 ft in 2002, with an estimated discharge of <1 cfs.

Habitat category	Index	Result	Characterization
<i>Overall habitat quality</i>	Habitat quality index (HQI)	79	Score is relative to a DEQ grade-C reference condition scoring 100 on a normalized scale
<i>Overall riparian quality</i>	QR1 index	0.70	Good
	RCOND index	0.67	Good
<i>Hydrologic flashiness</i>	Mean of Flashrt1, Flashrt2, and Flashrt3 indices	3.95	Signs of hydrologic impact
	Individual metric		
<i>Channel morphology</i>	Pool percentage (PCT_POOL)	29%	Does not meet recommended pool area
	Riffle percentage (as PCT_FAST)	36%	Does not meet recommended riffle area
<i>Residual pools</i>	Residual pool volume (TOTPVOL)	13.8 m ³	n/a
<i>Substrate composition</i>	Dominant substrate	77 %	Coarse gravel and larger particles
	Mean embeddedness (XEMBED)	37%	“Not properly functioning”
	Substrate sand and fines (PCT_SAFN)	19%	“At risk” (4% fines <0.6mm, 15% sand (0.6-2mm))
	D ₅₀ (median particle size, mm)	21	n/a
<i>Bed substrate stability</i>	Bed stability index (LRBS_BW4)	-0.42	Streambed relatively stable
<i>Fish cover</i>	Natural fish cover by area (XFC_NAT)	0.25	Fish cover minimal
<i>Large woody debris</i>	Total LWD density (C1W)	137/mile	“Not properly functioning” (low density and few large pieces)
<i>Riparian vegetation cover</i>	Stream shading mid-channel (XCDENMID)	91%	Well-shaded
<i>Human disturbance</i>	Riparian human disturbance index (W1_HALL)	0.26	n/a
<i>Invasive plant species</i>	Overall invasive plant proportion (ip_score) (individual species proportion)	1.64	Invasive plants common (English Ivy = 0.64, Him Black = 0.82, Reed Canary = 0.18)

Cougar Creek station CGR020 (2002)

Reach location and watershed description:

The Cougar Creek watershed has a drainage area of ~3 mi² above the index reach. Current land cover in the drainage is dominated by urban development. In the middle and lower watershed, Cougar Creek flows in a narrow canyon with intact riparian areas, while in the upper watershed the creek is heavily channelized and often piped. Stormwater inputs to Cougar Creek are widespread and consist primarily of pipe outlets from the storm sewer system. Road density above the index reach is ~19 mi/mi² (2001 data).

The index reach is located approximately ½ mile upstream of the confluence with Salmon Creek, approximately 100 ft upstream of 119th Street. The reach is characterized by pool-riffle morphology and a very low gradient (0.9%), but is also fairly straight with a low sinuosity of 1.2. Mean wetted width at baseflow was ~7 ft, with an estimated discharge of 1 cfs.

Habitat category	Index	Result	Characterization
<i>Overall habitat quality</i>	Habitat quality index (HQI)	54	Score is relative to a DEQ grade-C reference condition scoring 100 on a normalized scale
<i>Overall riparian quality</i>	QR1 index	0.58	Fair
	RCOND index	0.56	Medium
<i>Hydrologic flashiness</i>	Mean of Flashrt1, Flashrt2, and Flashrt3 indices	5.24	Obvious hydrologic impacts (most flashy LISP site in 2002)
	Individual metric		
<i>Channel morphology</i>	Pool percentage (PCT_POOL)	13%	Does not meet recommended pool area
	Riffle percentage (as PCT_FAST)	10%	Does not meet recommended riffle area
<i>Residual pools</i>	Residual pool volume (TOTPVOL)	4.0 m ³	n/a
<i>Substrate composition</i>	Dominant substrate	79%	Sand
	Mean embeddedness (XEMBED)	93%	“Not properly functioning”
	Substrate sand and fines (PCT_SAFN)	83%	“Not properly functioning” (4% fines <0.6mm, 79% sand (0.6-2mm))
	D ₅₀ (median particle size, mm)	0.5	n/a
<i>Bed substrate stability</i>	Bed stability index (LRBS_BW4)	-2.02	Streambed highly unstable
<i>Fish cover</i>	Natural fish cover by area (XFC_NAT)	0.78	Fish cover abundant
<i>Large woody debris</i>	Total LWD density (C1W)	253/mile	“Not properly functioning” (fair density but no large pieces)
<i>Riparian vegetation cover</i>	Stream shading (XC DENMID)	92%	Well-shaded
<i>Human disturbance</i>	Riparian human disturbance index (W1_HALL)	1.43	n/a
<i>Invasive plant species</i>	Overall invasive plant proportion (ip_score) (individual species proportion)	1.55	Invasive plants common (English Ivy = 0.00, Him Black = 0.73, Reed Canary = 0.82)

Curtin Creek station CUR020 (2002)

Reach location and watershed description:

The Curtin Creek watershed has a drainage area of 5.7 mi² above the index reach. Current land cover in the drainage is a mix of urban residential, rural residential, pasture, and agricultural land. There are remnants of large historical wetlands, but most historical forest and wetland areas have been cleared or altered. Much of the channel is man-made and channelized. Stormwater inputs to Curtin Creek consist of urban storm sewer outfalls in the upper watershed, and primarily roadside ditches in the middle and lower reaches. Road density above the index reach is ~13 mi/mi² (2001 data).

The index reach is located approximately 3/4 mile upstream of the confluence with Salmon Creek, just downstream of NE 139th Street. The reach morphology is characterized by long, slow glides and a very low gradient (0.6%), but is also fairly straight with a relatively low sinuosity of 1.3. Most of the LISP reach has recently been replanted with riparian vegetation after many years of cattle access. Mean wetted width at baseflow was ~12 ft, with an estimated discharge of ~3 cfs.

Habitat category	Index	Result	Characterization
<i>Overall habitat quality</i>	Habitat quality index (HQI)	41	Score is relative to a DEQ grade-C reference condition scoring 100 on a normalized scale
<i>Overall riparian quality</i>	QR1 index	0.49	Poor
	RCOND index	0.29	Poor
<i>Hydrologic flashiness</i>	Mean of Flashrt1, Flashrt2, and Flashrt3 indices	1.84	Minimal hydrologic impact
	Individual metric		
<i>Channel morphology</i>	Pool percentage (PCT_POOL)	0%	Does not meet recommended pool area
	Riffle percentage (as PCT_FAST)	0%	Does not meet recommended riffle area
<i>Residual pools</i>	Residual pool volume (TOTPVOL)	26.6 m ³	n/a
<i>Substrate composition</i>	Dominant substrate	76%	Sand
	Mean embeddedness (XEMBED)	100%	“Not properly functioning”
	Substrate sand and fines (PCT_SAFN)	98%	“Not properly functioning” (22% fines <0.6mm, 76% sand (0.6-2mm))
	D ₅₀ (median particle size, mm)	0.2	n/a
<i>Bed substrate stability</i>	Bed stability index (LRBS_BW4)	-2.15	Streambed highly unstable
<i>Fish cover</i>	Natural fish cover by area (XFC_NAT)	0.42	Fish cover relatively sparse
<i>Large woody debris</i>	Total LWD density (C1W)	127/mile	“Not properly functioning” (low density and no large pieces)
<i>Riparian vegetation cover</i>	Stream shading (XCDENMID)	56%	Poorly shaded
<i>Human disturbance</i>	Riparian human disturbance index (W1_HALL)	0.83	n/a
<i>Invasive plant species</i>	Overall invasive plant proportion (ip_score) (individual species proportion)	1.00	Reed canary grass dominant (English Ivy = 0, Him Black = 0, Reed Canary = 1.00)

Gee Creek station GEE050 (2002)

Reach location and watershed description:

The Gee Creek watershed has a drainage area of 9.5 mi² above the index reach. Current land cover in the drainage is a mix of rural residential, pasture, and agricultural land, with some urban development encroaching in the headwaters. The stream flows through somewhat steep-walled valleys with some intact riparian areas, but upland areas have been largely cleared of historical forest. Stormwater inputs to Gee Creek consist primarily of roadside ditches, with piped stormwater flows from Interstate 5 and urban developments in the headwaters. Road density above the index reach is ~7 mi/mi² (2001 data).

The index reach is located near the center of the watershed, several hundred feet downstream of Royle Road. The reach morphology is pool-riffle, with a low gradient (1.4%), but is also fairly straight with a low sinuosity of 1.2. Mean wetted width at baseflow was ~14 ft, with an estimated discharge of <1 cfs.

Habitat category	Index	Result	Characterization
<i>Overall habitat quality</i>	Habitat quality index (HQI)	91	Score is relative to a DEQ grade-C reference condition scoring 100 on a normalized scale
<i>Overall riparian quality</i>	QR1 index RCOND index	0.64 0.60	Good Good
<i>Hydrologic flashiness</i>	Mean of Flashrt1, Flashrt2, and Flashrt3 indices	3.47	Signs of hydrologic impact
	Individual metric		
<i>Channel morphology</i>	Pool percentage (PCT_POOL) Riffle percentage (as PCT_FAST)	58% 10%	Meets recommended pool area Does not meet recommended riffle area
<i>Residual pools</i>	Residual pool volume (TOTPVOL)	51.2 m ³	n/a
<i>Substrate composition</i>	Dominant substrate Mean embeddedness (XEMBED) Substrate sand and fines (PCT_SAFN) D ₅₀ (median particle size, mm)	53% 69% 36% 5	Coarse gravel and larger (>16mm) “Not properly functioning” “At risk” (7% fines <0.6mm, 29% sand (0.6-2mm)) n/a
<i>Bed substrate stability</i>	Bed stability index (LRBS_BW4)	-0.68	Streambed somewhat unstable
<i>Fish cover</i>	Natural fish cover by area (XFC_NAT)	0.36	Fish cover relatively sparse
<i>Large woody debris</i>	Total LWD density (C1W)	348/mile	“Not properly functioning” (good density and some large pieces, but not enough)
<i>Riparian vegetation cover</i>	Stream shading (XCDENMID)	71%	Moderately shaded
<i>Human disturbance</i>	Riparian human disturbance index (W1_HALL)	0.33	n/a
<i>Invasive plant species</i>	Overall invasive plant proportion (ip_score) (individual species proportion)	1.18	Reed canary grass dominant (English Ivy = 0.09, Him Black = 0.09, Reed Canary = 1.00)

Jones Creek station JNS060 (2002)

Reach location and watershed description:

The Jones Creek watershed has a drainage area of 2.1 mi² above the index reach. Current land cover in the drainage upstream of the index reach is entirely forest. The area has been logged historically, but no timber harvest activities have occurred for many years. Stormwater inputs to the Jones Creek reach are limited to overland flow from the surrounding forest land. There are no ditches or piped sources of stormwater. Road density above the index reach is ~2 mi/mi² (2001 data).

The index reach is located in the upper watershed, ~200 ft upstream of a water supply pond operated by the City of Camas. The reach morphology tends toward step-pool, with a high gradient (6.0%) and a very low sinuosity of 1.0. Mean wetted width at baseflow was ~12 ft, with an estimated discharge of 2 cfs.

Habitat category	Index	Result	Characterization
<i>Overall habitat quality</i>	Habitat quality index (HQI)	80	Score is relative to a DEQ grade-A/B reference condition scoring 100 on a normalized scale
<i>Overall riparian quality</i>	QR1 index	0.93	Good
	RCOND index	0.92	Best
<i>Hydrologic flashiness</i>	Mean of Flashrt1, Flashrt2, and Flashrt3 indices	3.28	Signs of hydrologic impact
	Individual metric		
<i>Channel morphology</i>	Pool percentage (PCT_POOL)	38%	Does not meet recommended pool area
	Riffle percentage (as PCT_FAST)	60%	Meets recommended riffle area
<i>Residual pools</i>	Residual pool volume (TOTPVOL)	3.9 m ³	n/a
<i>Substrate composition</i>	Dominant substrate	83%	Coarse gravel and larger (>16mm)
	Mean embeddedness (XEMBED)	10%	“Properly functioning”
	Substrate sand and fines (PCT_SAFN)	1%	“Properly functioning” (0% fines <0.6mm, 1% sand (0.6-2mm))
	D ₅₀ (median particle size, mm)	107	n/a
<i>Bed substrate stability</i>	Bed stability index (LRBS_BW4)	-0.26	Streambed relatively stable
<i>Fish cover</i>	Natural fish cover by area (XFC_NAT)	0.68	Fish cover relatively abundant
<i>Large woody debris</i>	Total LWD density (C1W)	243	“Not properly functioning” (fair density and some large pieces, but not enough)
<i>Riparian vegetation cover</i>	Stream shading (XCDENMID)	95%	Well-shaded
<i>Human disturbance</i>	Riparian human disturbance index (W1_HALL)	0.00	n/a
<i>Invasive plant species</i>	Overall invasive plant proportion (ip_score)	0.00	No invasive plant species noted

Matney Creek station MAT010 (2002)

Reach location and watershed description:

The Matney Creek watershed has a drainage area of 6.7 mi² above the index reach. Current land cover in the drainage upstream of the index reach is a mix of forest, rural residential development, and pasture. Riparian forest is somewhat intact in the upper and lower watershed, with pasture dominating the riparian zone in the mid-watershed. Stormwater inputs to the Matney Creek reach are primarily from roads and ditches. There is no piped storm sewer system in this area. Road density above the index reach is ~7 mi/mi² (2001 data).

The index reach is located near the bottom of the watershed, several hundred feet upstream of the confluence with Lacamas Creek, and approximately 200 feet upstream of NE 68th Street. The reach is dominated by pool-riffle morphology, with a low gradient (1.5%) and a moderate sinuosity of 1.5. Mean wetted width at baseflow was ~13 ft, with an estimated discharge of 1 cfs.

Habitat category	Index	Result	Characterization
<i>Overall habitat quality</i>	Habitat quality index (HQI)	88	Score is relative to a DEQ grade-C reference condition scoring 100 on a normalized scale
<i>Overall riparian quality</i>	QR1 index	0.83	Good
	RCOND index	0.76	Best
<i>Hydrologic flashiness</i>	Mean of Flashrt1, Flashrt2, and Flashrt3 indices	3.81	Signs of hydrologic impact
	Individual metric		
<i>Channel morphology</i>	Pool percentage (PCT_POOL)	35%	Does not meet recommended pool area
	Riffle percentage (as PCT_FAST)	25%	Does not meet recommended riffle area
<i>Residual pools</i>	Residual pool volume (TOTPVOL)	10.2 m ³	n/a
<i>Substrate composition</i>	Dominant substrate	80%	Coarse gravel and larger (>16mm)
	Mean embeddedness (XEMBED)	28%	“At risk”
	Substrate sand and fines (PCT_SAFN)	11%	“Properly functioning” (1% fines <0.6mm, 10% sand (0.6-2mm))
	D ₅₀ (median particle size, mm)	56	n/a
<i>Bed substrate stability</i>	Bed stability index (LRBS_BW4)	0.05	Streambed very stable
<i>Fish cover</i>	Natural fish cover by area (XFC_NAT)	0.48	Fish cover relatively sparse
<i>Large woody debris</i>	Total LWD density (C1W)	285/mile	“Not properly functioning” (fair density and some large pieces, but not enough)
<i>Riparian vegetation cover</i>	Stream shading (XCDENMID)	95%	Well-shaded
<i>Human disturbance</i>	Riparian human disturbance index (W1_HALL)	0.32	n/a
<i>Invasive plant species</i>	Overall invasive plant proportion (ip_score)	0.00	No invasive plant species noted

Mill Creek station MIL010 (2002)

Reach location and watershed description:

The Mill Creek watershed has a drainage area of 11.6 mi² above the index reach. Current land cover in the drainage upstream of the index reach is dominated by rural residential development and pasture. Urban development is accelerating in the headwaters due to rapid growth in the city of Battleground. Most historical wetlands and forest have been cleared or altered. Stormwater inputs to the Mill Creek reach are primarily from roads and ditches in the middle and lower watershed, with urban stormwater system inputs in the upper watershed. Road density above the index reach is ~8 mi/mi² (2001 data).

The index reach is located near the bottom of the watershed, several hundred feet upstream of the confluence with Salmon Creek at Salmon Creek Avenue. The reach is dominated by pool-riffle morphology, with a low gradient (1.4%) and a moderate sinuosity of 1.5. The reach has been the subject of recent habitat improvement projects by Washington State University, including the placement of LWD. Mean wetted width at baseflow was ~14 ft, with an estimated discharge of <1 cfs.

Habitat category	Index	Result	Characterization
<i>Overall habitat quality</i>	Habitat quality index (HQI)	99	Score is relative to a DEQ grade-C reference condition scoring 100 on a normalized scale
<i>Overall riparian quality</i>	QR1 index	0.78	Good
	RCOND index	0.81	Good
<i>Hydrologic flashiness</i>	Mean of Flashrt1, Flashrt2, and Flashrt3 indices	3.53	Signs of hydrologic impact
	Individual metric		
<i>Channel morphology</i>	Pool percentage (PCT_POOL)	54%	Meets recommended pool area
	Riffle percentage (as PCT_FAST)	16%	Does not meet recommended riffle area
<i>Residual pools</i>	Residual pool volume (TOTPVOL)	45.8 m ³	n/a
<i>Substrate composition</i>	Dominant substrate	66%	Coarse gravel and larger (>16mm)
	Mean embeddedness (XEMBED)	43%	“Not properly functioning”
	Substrate sand and fines (PCT_SAFN)	18%	“At risk” (3% fines <0.6mm, 15% sand (0.6-2mm))
	D ₅₀ (median particle size, mm)	21	n/a
<i>Bed substrate stability</i>	Bed stability index (LRBS_BW4)	-0.37	Streambed relatively stable
<i>Fish cover</i>	Natural fish cover by area (XFC_NAT)	0.47	Fish cover relatively sparse
<i>Large woody debris</i>	Total LWD density (C1W)	433/mile	“Not properly functioning” (good density and some large pieces, but not enough)
<i>Riparian vegetation cover</i>	Stream shading (XCDENMID)	84%	Well-shaded
<i>Human disturbance</i>	Riparian human disturbance index (W1_HALL)	0.18	n/a
<i>Invasive plant species</i>	Overall invasive plant proportion (ip_score) (individual species proportion)	1.73	Invasive plants common (English Ivy = 0, Him Black = 0.73, Reed Canary = 1.00)

Whipple Creek station WPL050**(2002)***Reach location and watershed description:*

The Whipple Creek watershed has a drainage area of 8.2 mi² above the index reach. Current land cover in the drainage upstream of the index reach is a mix of rural residential development and pasture in the middle watershed, with urban residential development prevalent in the headwaters. Most historical upland forest has been cleared, but some intact forested riparian areas remain in the middle and lower watershed as the stream runs through fairly narrow canyons. Stormwater inputs to Whipple Creek above the index reach are primarily from roads and ditches in the middle watershed, with urban stormwater system inputs in the upper watershed. Road density above the index reach is ~9 mi/mi² (2001 data).

The index reach is located near the middle of the watershed, approximately two hundred feet upstream of NW 41st Avenue. The reach is characterized by pool-riffle morphology with a low gradient (1.2%), but also low sinuosity of 1.2. Mean wetted width at baseflow was ~14 ft, with an estimated discharge of ~1.5 cfs.

Habitat category	Index	Result	Characterization
<i>Overall habitat quality</i>	Habitat quality index (HQI)	71	Score is relative to a DEQ grade-C reference condition scoring 100 on a normalized scale
<i>Overall riparian quality</i>	QR1 index	0.70	Good
	RCOND index	0.68	Good
<i>Hydrologic flashiness</i>	Mean of Flashrt1, Flashrt2, and Flashrt3 indices	4.13	Obvious hydrologic impact
	Individual metric		
<i>Channel morphology</i>	Pool percentage (PCT_POOL)	27%	Does not meet recommended pool area
	Riffle percentage (as PCT_FAST)	19%	Does not meet recommended riffle area
<i>Residual pools</i>	Residual pool volume (TOTPVOL)	19.8 m ³	n/a
<i>Substrate composition</i>	Dominant substrate	61%	Fine gravel and smaller (<=16mm)
	Mean embeddedness (XEMBED)	86%	“Not properly functioning”
	Substrate sand and fines (PCT_SAFN)	46%	“Not properly functioning” (22% fines <0.6mm, 25% sand (0.6-2mm))
	D ₅₀ (median particle size, mm)	1.2	n/a
<i>Bed substrate stability</i>	Bed stability index (LRBS_BW4)	-1.63	Streambed relatively unstable
<i>Fish cover</i>	Natural fish cover by area (XFC_NAT)	0.52	Fish cover relatively abundant
<i>Large woody debris</i>	Total LWD density (C1W)	401/mile	“Not properly functioning” (good density and some large pieces, but not enough)
<i>Riparian vegetation cover</i>	Stream shading (XCDENMID)	73%	Moderately shaded
<i>Human disturbance</i>	Riparian human disturbance index (W1_HALL)	0.78	n/a
<i>Invasive plant species</i>	Overall invasive plant proportion (ip_score) (individual species proportion)	1.27	Invasive plants common (English Ivy = 0.09, Him Black = 0.55, Reed Canary = 0.64)

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Appendix A

Clark County EMAP "useful metrics"											
	= EMAPs 18 recommended "most useful" metrics from the list of 49 "most frequently used"										
	= additional useful metrics from list of 49 "most frequently used"										
	= remainder of EMAP 49 "most frequently used" metrics										
	= additional useful metrics from list of 250+ EMAP metrics										
SITE_ID	Description	BRZD10	CGR020	CUR020	GEED50	JNS060	MAT010	MIL010	WPL050	RMSE	S/N
Channel morphology											
XDEPTH	Mean thalweg depth (cm)	17	20	45	36	21	21	33	24	6.2	6.9
SDDEPTH	Standard deviation of thalweg depth (cm)	11	7	12	24	8	9	22	12	3.4	6.0
XWIDTH	Mean wetted width (m)	3.45	2.20	3.54	4.31	3.62	3.95	4.11	4.12	0.9	14.0
XWXD	Mean wetted width x depth (m2)	0.46	0.41	1.66	1.71	0.86	0.87	1.44	1.06	0.8	8.1
PCT_FAST	Percent falls + cascades + rapids + riffles	36	10	0	10	60	25	16	19	12.0	7.6
PCT_SLOW	Percent glides + all pool types	64	90	100	90	40	75	84	81	12.0	7.5
PCT_POOL	Percent all pool types	29	13	0	38	38	35	54	27	16.0	2.1
Channel X-sec and bank morphology											
XBKF_W	Mean bankfull width (m)	4.86	3.53	4.39	8.68	6.32	6.03	8.01	5.83	1.1	24.0
XBKF_H	Mean bankfull height (m)	0.34	0.62	0.29	0.52	0.38	0.44	0.47	0.54	0.13	3.5
XINC_H	Mean incision height (m)	0.47	1.00	0.42	1.46	0.65	0.95	1.46	1.83	0.76	0.8
Channel sinuosity and slope											
SINU	Channel sinuosity	1.2	1.2	1.3	1.2	1.0	1.4	1.5	1.2	0.25	1.1
XSLOPE	Water surface gradient over reach (%)	1.9	0.9	0.6	1.4	6.0	1.5	1.4	1.2	0.87	24.0
Residual pool											
RP100	Mean residual depth (m2/100m reach length) = cm	7	5	19	21	4	8	19	11	2.2	9.0
TOTPVOL	Residual volume for the entire reach (m3/reach)	13.8	4.0	26.6	51.2	3.9	10.2	45.8	19.8	n/a	n/a
Substrate size and composition											
LSUB_DMM	Log10[estimated geometric mean substrate diameter (mm)]	1.33	-0.35	-0.83	0.72	2.03	1.75	1.33	0.09	0.32	24.0
XEMBED	Substrate mean embededness- channel + margin (%)	37	93	100	69	10	28	43	86	9.5	7.7
PCT_BDRK	Substrate % bedrock	6	0	0	0	0	16	11	0	4.0	3.9
PCT_BIGR	Substrate % coarse gravel and larger (>16mm)	77	0	0	53	83	80	66	35	8.1	16.0
PCT_SFQF	Substrate % fine gravel and smaller (<=16mm)	20	97	98	42	15	19	32	61	12.0	5.0
PCT_SA	Substrate % sand (0.6-2mm)	15	79	76	29	1	10	15	25	7.9	0.1
PCT_FN	Substrate % fine (silt/clay)	4	4	22	7	0	1	3	22	7.4	15.0
PCT_SAFN	Substrate % sand + fines (<2mm)	19	83	98	36	1	10	18	46	11.0	7.1
PCT_RC	Substrate % concrete	0	0	0	0	0	0	0	0	n/a	n/a
PCT_HP	Substrate % hardpan	0	0	0	0	0	0	0	0	3.0	12.0
Bed substrate stability											
LTEST	Log10[Erodible substrate diameter (mm)]--estimate 1	1.36	1.09	1.24	1.55	1.93	1.32	1.50	1.30	0.27	7.4
LDME_BW4	Log10[Erodible substrate diameter (mm)]--estimate 2	1.75	1.67	1.32	1.40	2.28	1.70	1.70	1.72	n/a	n/a
LRBS_TST	Log10[Relative Bed Stability]-- estimate 1	-0.04	-1.44	-2.07	-0.83	0.09	0.43	-0.17	-1.21	0.4	6.8
LRBS_BW4	Log10[Relative Bed Stability]--estimate 2	-0.42	-2.02	-2.15	-0.68	-0.26	0.05	-0.37	-1.63	n/a	n/a
Fish cover											
XFC_ALG	Filamentous algae areal cover	0.000	0.015	0.005	0.009	0.000	0.000	0.000	0.000	0.089	0.9
XFC_AQM	Aquatic macrophyte areal cover	0.00	0.00	0.20	0.15	0.00	0.00	0.00	0.00	0.068	2.8
XFC_LWD	Large woody debris areal cover	0.04	0.11	0.01	0.08	0.07	0.06	0.08	0.10	0.036	3.9
XFC_BRS	Brush and small woody debris areal cover	0.08	0.16	0.04	0.02	0.15	0.07	0.05	0.08	0.065	1.0
XFC_OHV	Overhanging vegetation areal cover	0.09	0.42	0.31	0.23	0.16	0.30	0.30	0.29	0.069	5.1
XFC_NAT	Sum of cover from large wood, brush, overhanging vegetation, boulders and undercut banks	0.25	0.78	0.42	0.36	0.68	0.48	0.47	0.52	0.18	2.8
XFC_BIG	Sum of cover from large wood, boulders, overhanging banks and human structures	0.08	0.19	0.06	0.11	0.36	0.11	0.11	0.16	0.14	2.9
XFC_UCB	Undercut bank areal cover	0.04	0.08	0.05	0.03	0.02	0.01	0.02	0.05	0.040	6.2
LWD metric variables											
C1W	LWD in active channel (pieces/reach) --size class 1	13	24	12	33	23	27	41	38	n/a	n/a
C2W	LWD in active channel (pieces/reach) --size class 2	6	1	3	24	13	14	18	19	n/a	n/a
C3W	LWD in active channel (pieces/reach) --size class 3	2	0	0	15	4	7	7	1	n/a	n/a
C4W	LWD in active channel (pieces/reach) --size class 4	0	0	0	9	3	1	2	0	n/a	n/a

Appendix A continued.....

Clark County EMAP "useful metrics"												
	= EMAPs 18 recommended "most useful" metrics from the list of 49 "most frequently used"											
	= additional useful metrics from list of 49 "most frequently used"											
	= remainder of EMAP 49 "most frequently used" metrics											
	= additional useful metrics from list of 250+ EMAP metrics											
SITE_ID	Description	BRZ010	CGR020	CUR020	GEE050	JNS060	MAT010	MIL010	WPL050	RMSE	S/N	
C5W	LWD in active channel (pieces/reach) -- size class 5	0	0	0	2	0	0	0	0	n/a	n/a	
V1W_MSQ	LWD volume in active channel(m3/m2)- size classes 1	0.004	0.003	0.003	0.069	0.016	0.013	0.015	0.009	n/a	n/a	
V2W_MSQ	LWD volume in active channel(m3/m2)- size classes 2	0.003	0.000	0.002	0.068	0.015	0.012	0.014	0.008	n/a	n/a	
V3W_MSQ	LWD volume in active channel(m3/m2)- size classes 3	0.002	0.000	0.000	0.066	0.010	0.010	0.009	0.001	n/a	n/a	
V4W_MSQ	LWD volume in active channel(m3/m2)- size classes 4	0.000	0.000	0.000	0.060	0.009	0.003	0.005	0.000	n/a	n/a	
V5W_MSQ	LWD volume in active channel(m3/m2)- size classes 5	0.000	0.000	0.000	0.034	0.000	0.000	0.000	0.000	n/a	n/a	
V1TM100	LWD volume in and above active channel (m3/100m)- size classes 1	1.76	1.00	1.39	60.50	9.87	8.61	11.82	5.16	n/a	n/a	
Riparian cover (densiometer)												
XCDENBK	Mean % canopy density at bank	91	93	60	82	97	98	96	88	3.9	17.0	
XCDENMID	Mean % canopy density midstream	89	92	56	71	95	95	84	73	5.8	15.0	
Riparian vegetation cover/structure												
XCL	Riparian canopy (>5m high) cover-trees >0.3m DBH	0.48	0.45	0.08	0.41	0.48	0.39	0.56	0.45	0.057	4.6	
XGB	Riparian ground-layer (<0.5 m high) bare ground cover	0.06	0.11	0.11	0.07	0.05	0.11	0.08	0.09	0.070	2.0	
XC	Riparian canopy cover (XCL + XCS)	0.63	0.64	0.26	0.46	0.83	0.87	0.64	0.50	0.12	2.4	
XCM	Riparian canopy + mid-layer cover (XC + XCM)	1.30	1.37	0.87	1.26	1.77	1.68	1.47	1.36	0.27	0.8	
XCMGW	Riparian woody cover, sum of 3 layers (XC + XCMW + XGW)	0.81	0.92	0.55	0.69	1.62	1.49	1.09	0.94	0.36	0.7	
XPCAN	Riparian canopy presence (proportion of reach)	0.95	1.00	0.73	0.73	1.00	1.00	1.00	0.79	0.08	10.0	
XPCM	Riparian canopy and mid-layer presence (proportion of reach)	0.95	1.00	0.73	0.73	1.00	1.00	1.00	0.79	0.08	7.9	
XPCMG	3-layer riparian vegetation presence (proportion of reach)	0.95	1.00	0.68	0.73	1.00	1.00	1.00	0.79	0.08	8.0	
PCAN_C	Coniferous riparian canopy presence (proportion of reach)	0.00	0.05	0.00	0.00	0.14	0.00	0.00	0.00	0.11	8.5	
Human disturbance												
WIH_WALL	Riparian human disturbance-- channel revetment (proximity-weighted index)	0	0	0	0	0	0	0	0	0.17	0.0	
WIH_LOG	Riparian human disturbance-- logging (proximity-weighted index)	0	0	0	0	0	0	0	0	0.36	0.3	
W1_HALL	Riparian human disturbance index (proximity-weighted sum)	0.26	1.43	0.83	0.33	0.00	0.32	0.18	0.33	0.78	0.9	
W1_HNOAG	Riparian human disturbance index-- non-agricultural types (proximity-weighted sum)	0.26	1.43	0.33	0.07	0.00	0.29	0.00	0.33	0.76	0.9	
W1_HAG	Riparian human disturbance index -- agricultural types (proximity-weighted sum)	0.00	0.00	0.50	0.26	0.00	0.03	0.18	0.00	0.12	8.8	
Invasive plant species												
ip_score	Riparian invasive plant species (sum of all types present- proportion of reach)	1.64	1.55	1.00	1.18	0.00	0.00	1.73	1.27	n/a	n/a	
f_ENGVY	English ivy invasive plant (proportion of reach where present)	0.64	0.00	0.00	0.09	0.00	0.00	0.00	0.09	n/a	n/a	
f_HIMBLA	Himalayan blackberry invasive plant (proportion of reach where present)	0.82	0.73	0.00	0.09	0.00	0.00	0.73	0.55	n/a	n/a	
f_REECAN	Reed canary grass invasive plant (proportion of reach where present)	0.18	0.82	1.00	1.00	0.00	0.00	1.00	0.64	n/a	n/a	

Appendix B

Inclusion of Recommended PHAB metrics based on urban/stormwater impact and expected measurable response								
	Montgomery and MacDonald 2002	Montgomery and MacDonald 2002						
Booth and Scholz 1998	(chronic increase fines) (Pool-riffle channel response)	(increase freq and mag of peak) (Pool-riffle channel response)	May 1997	Directly from EMAP	Derivable from EMAP	Not derivable from EMAP	Currently in report	Comment on usage
gradient				X			X	stand-alone and bed stability index
shade/canopy (dens)				X			X	stand-alone and riparian condition index
bank erosion		bank erosion				X		visual estimate (e.g. Henshaw) or photo record
LWD tally			LWD frequency	X			X	stand-alone
substrate composition				X			X	stand-alone and habitat index
pools tally			pool frequency		X			
	D50	D50		X			X	stand-alone
	D16	D16			X			can be calculated from raw data, not from metric:
	D50 in pools	D50 in pools				X		EMAP does not distinguish pool substrate
	percent fines (<2mm)	percent fines (<2mm)		X			X	stand-alone
	embeddedness	embeddedness	embeddedness %	X			X	stand-alone
	pool volume	pool volume		X			X	stand-alone
	residual depth	residual depth		X			X	flashiness index
	*V (? undefined)	*V (? undefined)						
	thalweg profiles	thalweg profiles		X				
	suspended load	suspended load				X		EMAP does not measure sediment transport
		bankfull width		X			X	flashiness index
		bankfull depth		X			X	flashiness index
		channel scour				X		EMAP does not measure channel scour
		bedload				X		EMAP does not measure bedload transport
			Qualitative habitat index	X				
			LWD volume	X				
			streambank stability rating			X		visual estimate (e.g. Henshaw) or photo record
			% pool habitat	X			X	stand-alone
			% glide habitat		X		X	can be calculated from % pools and % fast
			% pool cover	X				
							additional metrics:	
							mean thalweg depth	flashiness index
							mean wetted width	stand-alone
							mean wetted area	flashiness index
							% fast habitat	stand-alone: allows calculation of % glide
							sinuosity	stand-alone
							substrate % gravel+	habitat index
							bed stability index	stand-alone index
							fish cover	stand-alone and habitat index
							riparian canopy %	riparian condition index
							riparian 3-layer woody cover	riparian condition index
							invasive plant +/-	stand-alone
							human disturbance index	riparian condition index
red = not used in 2002 LISP habitat summary								

Appendix B continued....1996 NMFS Matrix of Pathways and Indicators

TABLE 1. MATRIX of PATHWAYS AND INDICATORS

(Remember, the ranges of criteria presented here are not absolute, they may be adjusted for unique watersheds. See p. 3)

PATHWAY	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Water Quality:	Temperature	50-57° F ¹	57-60° (spawning) 57-64° (migration & rearing) ²	> 60° (spawning) > 64° (migration & rearing) ²
	Sediment/Turbidity	< 12% fines (<0.85mm) in gravel ¹ , turbidity low	12-17% (west-side) ¹ , 12-20% (east-side) ² , turbidity moderate	>17% (west-side) ¹ , >20% (east side) ² fines at surface or depth in spawning habitat ² , turbidity high
	Chemical Contamination/ Nutrients	low levels of chemical contamination from agricultural, industrial and other sources, no excess nutrients, no CWA 303d designated reaches ⁴	moderate levels of chemical contamination from agricultural, industrial and other sources, some excess nutrients, one CWA 303d designated reach ⁴	high levels of chemical contamination from agricultural, industrial and other sources, high levels of excess nutrients, more than one CWA 303d designated reach ⁴
Habitat Access:	Physical Barriers	any man-made barriers present in watershed allow upstream and downstream fish passage at all flows	any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at base/low flows	any man-made barriers present in watershed do not allow upstream and/or downstream fish passage at a range of flows
Habitat Elements:	Substrate	dominant substrate is gravel or cobble (interstitial spaces clear), or embeddedness <20% ³	gravel and cobble is subdominant, or if dominant, embeddedness 20-30% ⁴	bedrock, sand, silt or small gravel dominant, or if gravel and cobble dominant, embeddedness >30% ²
	Large Woody Debris	Coast: >80 pieces/mile >24" diameter >50 ft. length ⁴ ; East-side: >20 pieces/ mile >12" diameter >35 ft. length ² ; and adequate sources of woody debris recruitment in riparian areas	currently meets standards for properly functioning, but lacks potential sources from riparian areas of woody debris recruitment to maintain that standard	does not meet standards for properly functioning and lacks potential large woody debris recruitment

Appendix B continued....1996 NMFS Matrix of Pathways and Indicators

	Pool Frequency	meets pool frequency standards (left) and large woody debris recruitment standards for properly functioning habitat (above)	meets pool frequency standards but large woody debris recruitment inadequate to maintain pools over time	does not meet pool frequency standards																		
	<table><tr><td>channel width</td><td># pools/mile *</td></tr><tr><td>5 feet</td><td>184</td></tr><tr><td>10 "</td><td>96</td></tr><tr><td>15 "</td><td>70</td></tr><tr><td>20 "</td><td>56</td></tr><tr><td>25 "</td><td>47</td></tr><tr><td>50 "</td><td>26</td></tr><tr><td>75 "</td><td>23</td></tr><tr><td>100 "</td><td>18</td></tr></table>	channel width	# pools/mile *	5 feet	184	10 "	96	15 "	70	20 "	56	25 "	47	50 "	26	75 "	23	100 "	18			
	channel width	# pools/mile *																				
	5 feet	184																				
	10 "	96																				
15 "	70																					
20 "	56																					
25 "	47																					
50 "	26																					
75 "	23																					
100 "	18																					
Pool Quality	pools >1 meter deep (holding pools) with good cover and cool water ³ , minor reduction of pool volume by fine sediment	few deeper pools (>1 meter) present or inadequate cover/temperature ³ , moderate reduction of pool volume by fine sediment	no deep pools (>1 meter) and inadequate cover/temperature ³ , major reduction of pool volume by fine sediment																			
Off-channel Habitat	backwaters with cover, and low energy off-channel areas (ponds, oxbows, etc.) ¹	some backwaters and high energy side channels ³	few or no backwaters, no off-channel ponds ³																			
Refugia (important remnant habitat for sensitive aquatic species)	habitat refugia exist and are adequately buffered (e.g., by intact riparian reserves); existing refugia are sufficient in size, number and connectivity to maintain viable populations or sub-populations ⁷	habitat refugia exist but are not adequately buffered (e.g., by intact riparian reserves); existing refugia are insufficient in size, number and connectivity to maintain viable populations or sub-populations ⁷	adequate habitat refugia do not exist ⁷																			
Channel Condition & Dynamics:	Width/Depth Ratio	<10 ^{2,4}	10-12 (we are unaware of any criteria to reference)	>12 (we are unaware of any criteria to reference)																		
	Streambank Condition	>90% stable; i.e., on average, less than 10% of banks are actively eroding ²	80-90% stable	<80% stable																		
	Floodplain Connectivity	off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession	reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function, riparian vegetation/succession	severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetland extent drastically reduced and riparian vegetation/succession altered significantly																		

Appendix B continued....1996 NMFS Matrix of Pathways and Indicators

Flow/Hydrology:	Change in Peak/ Base Flows	watershed hydrograph indicates peak flow, base flow and flow timing characteristics comparable to an undisturbed watershed of similar size, geology and geography	some evidence of altered peak flow, baseflow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography	pronounced changes in peak flow, baseflow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography
	Increase in Drainage Network	zero or minimum increases in drainage network density due to roads ^{a,9}	moderate increases in drainage network density due to roads (e.g., 5%) ^{a,9}	significant increases in drainage network density due to roads (e.g., 20-25%) ^{a,9}
Watershed Conditions:	Road Density & Location	<2 mi/mi ² ¹¹ , no valley bottom roads	2-3 mi/mi ² , some valley bottom roads	>3 mi/mi ² , many valley bottom roads
	Disturbance History	<15% ECA (entire watershed) with no concentration of disturbance in unstable or potentially unstable areas, and/or refugia, and/or riparian area; and for NWFP area (except AMAs), 15% retention of LSOG in watershed ^{d,10}	<15% ECA (entire watershed) but disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian area; and for NWFP area (except AMAs), 15% retention of LSOG in watershed ^{d,10}	>15% ECA (entire watershed) and disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian area; does not meet NWFP standard for LSOG retention
	Riparian Reserves	the riparian reserve system provides adequate shade, large woody debris recruitment, and habitat protection and connectivity in all subwatersheds, and buffers or includes known refugia for sensitive aquatic species (>80% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/ composition >50% ¹²	moderate loss of connectivity or function (shade, LWD recruitment, etc.) of riparian reserve system, or incomplete protection of habitats and refugia for sensitive aquatic species (70-80% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/composition 25-50% or better ¹²	riparian reserve system is fragmented, poorly connected, or provides inadequate protection of habitats and refugia for sensitive aquatic species (<70% intact), and/or for grazing impacts: percent similarity of riparian vegetation to the potential natural community/composition <25% ¹²

¹ Bjornn, T.C. and D.W. Reiser, 1991. Habitat Requirements of Salmonids in Streams. American Fisheries Society Special Publication 19:83-138. Meehan, W.R., ed.

² Biological Opinion on Land and Resource Management Plans for the: Boise, Challis, Nez Perce, Payette, Salmon, Sawtooth, Umatilla, and Wallowa-Whitman National Forests. March 1, 1995.

³ Washington Timber/Fish Wildlife Cooperative Monitoring Evaluation and Research Committee, 1993. Watershed Analysis Manual (Version 2.0). Washington Department of Natural Resources.

⁴ Biological Opinion on Implementation of Interim Strategies for Managing Anadromous Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California (PACFISH). National Marine Fisheries Service, Northwest Region, January 23, 1995.

⁵ A Federal Agency Guide for Pilot Watershed Analysis (Version 1.2), 1994.

⁶ USDA Forest Service, 1994. Section 7 Fish Habitat Monitoring Protocol for the Upper Columbia River Basin.

⁷ Frissell, C.A., Liss, W.J., and David Bayles, 1993. An Integrated Biophysical Strategy for Ecological Restoration of Large Watersheds. Proceedings from the Symposium on

Appendix B continued....1996 NMFS Matrix of Pathways and Indicators

Changing Roles in Water Resources Management and Policy, June 27-30, 1993 (American Water Resources Association), p. 449-456.

⁸ Wemple, B.C., 1994. Hydrologic Integration of Forest Roads with Stream Networks in Two Basins, Western Cascades, Oregon. M.S. Thesis, Geosciences Department, Oregon State University.

⁹ e.g., see Elk River Watershed Analysis Report, 1995. Siskiyou National Forest, Oregon.

¹⁰ Northwest Forest Plan, 1994. Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl. USDA Forest Service and USDI Bureau of Land Management.

¹¹ USDA Forest Service, 1993. Determining the Risk of Cumulative Watershed Effects Resulting from Multiple Activities.

¹² Winward, A.H., 1989. Ecological Status of Vegetation as a base for Multiple Product Management. Abstracts 42nd annual meeting, Society for Range Management, Billings MT, Denver CO: Society For Range Management: p277.

Appendix C

METRIC_ID	Description	BRZ010	CGR020	CUR020	GED050	MAT010	MIL010	WPL050	Muddy Cr	Williams Cr	Ref avg	JNS060	Wanderer's Cr	Shortridge Cr	Ref avg
Habitat Quality Index (Glen Merritt)									C	C			A	B	
SDWXD	Standard deviation of (thalweg depth x wetted width)	0.33	0.15	0.63	1.43	0.44	1.31	0.68	1.72	0.27	1.00	0.42	0.52	0.63	0.58
PCT_BIGR	Substrate % coarse gravel and larger (>16mm)	77	0	0	53	80	86	95	2	75	39	83	93	76	85
XFC_BIG	Sum of cover from large wood, boulders, banks and structures	0.08	0.19	0.06	0.11	0.11	0.11	0.16	0.33	0.40	0.36	0.36	0.70	0.74	0.72
XCDENMID	Mean % canopy density midstream	89	92	56	71	95	84	73	69	82	76	95	94	94	94
SDWXD	individual metric HQI score	0.23	0.10	0.44	1.00	0.31	0.92	0.47				0.70			0.99
PCT_BIGR	individual metric HQI score	0.96	0.00	0.00	0.66	1.00	0.82	0.44				0.48			0.99
XFC_BIG	individual metric HQI score	0.21	0.53	0.18	0.31	0.30	0.31	0.43				1.01			1.00
XCDENMID	individual metric HQI score	0.94	0.97	0.59	0.75	0.99	0.89	0.76				0.80			0.99
	Sum of individual metric scores	2.35	1.60	1.21	2.72	2.61	2.94	2.12				2.98			3.98
	Composite HQI	79	54	41	91	88	99	71				100			100
METRIC_ID	Description	BRZ010	CGR020	CUR020	GED050	MAT010	MIL010	WPL050				JNS060			
Riparian condition index (QR1) Butkus, 2002 305 (b), by Kaufmann															
QR1	QR1 = geometric mean of QRveg1, QRveg2, and QRDIST1														
XCMGW	Riparian woody cover, sum of 3 layers (XC + XMW + XGW)	0.81	0.92	0.55	0.69	1.49	1.09	0.94				1.62			
QRveg1	Since XCMGW <= 2.0, QRveg1 = 0.1 + (0.9*(XCMGW/2.00))	0.46	0.51	0.35	0.41	0.77	0.59	0.52				0.83			
XCDENBK	Mean % canopy density at bank	91	93	60	82	96	96	88				97			
QRveg2	QRveg2 = 0.1 + (0.9*(XCDENBK/100))	0.92	0.94	0.64	0.84	0.96	0.96	0.89				0.98			
W1_HALL	Riparian human disturbance index (proximity-weighted sum)	0.26	1.43	0.83	0.33	0.32	0.18	0.33				0.00			
QRDIST1	QRDIST1 = 1/(1 + W1_HALL)	0.80	0.41	0.55	0.75	0.76	0.85	0.75				1.00			
QR1	geometric mean of QRveg1, QRveg2, and QRDIST1	0.70	0.58	0.49	0.64	0.83	0.78	0.70				0.93			
		good	fair	poor	good	good	good	good				good			
METRIC_ID	Description	BRZ010	CGR020	CUR020	GED050	MAT010	MIL010	WPL050				JNS060			
Riparian condition index (RCOND) Kaufmann															
RCOND	RCOND = geo mean of XCL, XCMGW, 1/(1 + W1_HALL)														
XCL	Riparian canopy (>5m high) cover-trees >0.3 m DBH	0.48	0.45	0.08	0.41	0.39	0.56	0.45				0.48			
XCMGW	Riparian woody cover, sum of 3 layers (XC + XMW + XGW)	0.81	0.92	0.55	0.69	1.49	1.09	0.94				1.62			
W1_HALL	Riparian human disturbance index (proximity-weighted sum)	0.26	1.43	0.83	0.33	0.32	0.18	0.33				0.00			
1/(1+W1_HALL)		0.80	0.41	0.55	0.75	0.76	0.85	0.75				1.00			
RCOND		0.67	0.56	0.29	0.60	0.76	0.81	0.68				0.92			
		good	medium	poor	good	best	good	good				best			
METRIC_ID	Description	BRZ010	CGR020	CUR020	GED050	MAT010	MIL010	WPL050				JNS060			
Hydrologic flashiness (Kaufmann)															
Flashht1															
XBKF_H	Mean bankfull height (m)	0.34	0.62	0.29	0.52	0.44	0.47	0.54				0.38			
XDEPTH	Mean thalweg depth (cm)	17	20	45	36	21	33	24				21			
Flashht1	((100*(XBKF_H) + XDEPTH)/XDEPTH)	2.94	4.12	1.65	2.42	3.07	2.44	3.27				2.83			
Flashht2															
XBKF_H	Mean bankfull height (m)	0.34	0.62	0.29	0.52	0.44	0.47	0.54				0.38			
XDEPTH	Mean thalweg depth (cm)	17	20	45	36	21	33	24				21			
RP100	Mean residual depth (m2/100m reach length) = cm	7	5	19	21	8	19	11				4			
Flashht2	((100*(XBKF_H) + XDEPTH * RP100)/(XDEPTH * RP100))	4.30	5.25	2.10	4.36	4.32	4.51	5.17				3.22			
Flashht3															
XBKF_H	Mean bankfull height (m)	0.34	0.62	0.29	0.52	0.44	0.47	0.54				0.38			
XBKF_W	Mean bankfull width (m)	4.86	3.53	4.39	8.68	6.03	8.01	5.83				6.32			
XWXD	Mean wetted width x depth (m2)	0.46	0.41	1.66	1.71	0.87	1.44	1.06				0.86			
Flashht3	((XBKF_H*(XBKF_W) + xwxd)/xwxd)	4.60	6.35	1.78	3.62	4.04	3.63	3.95				3.80			